



Natural Resources
Canada



Energy
Technology
Futures

Results from the Buildings Focus Group

Held on November 4th, 1998
National Research Council
Ottawa, Ontario
Compiled by Paul Khanna 16/03/99

Canada

DISCLAIMER

This document is the final draft using information from the November 4th focus group and the Marbek Resource Consultants report on Space Conditioning and Illumination. As part of an ongoing editing exercise, please direct any corrections or comments to Paul Khanna at (613) 943-9216 or email pkhanna@nrcan.gc.ca.

INTRODUCTION

The Energy Technology Futures branch organized a focus group on building technology on November 4th, 1998 to reinforce and expand on our existing information and understanding. It also served to bring together a diverse group of people in the field of building science covering many aspects of this broad topic. The meeting was held at the National Research Council building in downtown Ottawa, Ontario.

BACKGROUND

Mission Statement

The session started at 8:30 AM and went on to finish at 4:30 PM. It began with a presentation of the Energy Technology Futures project and a mission statement for the day. The charge to the group was to:

- Develop a vision of building technology in a GHG reducing (or neutral) environment.
- Identify possible building technologies that could be used in the 2030 – 2050 time frame.
- Describe research and development priorities, technical gaps, and critical technologies for the area.

The morning clarification session was followed by small group sessions discussing building scenarios in the 2030-2050 time frame. Then the groups reported back to the plenary session to discuss their findings. After lunch the group broke up into groups of two to expand on their ideas and develop systems to be incorporated into the mornings scenarios. In the last hour a roundtable discussion transpired concerning the ETF process and the role of the federal government in the field of building technology

Contributors

The focus group had eleven attendees as well as representatives from the Energy Technology Futures office. These included contributors from many areas of the government. The list of attendees is as follows:

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Bill Eggartson, Executive Director, Canadian Earth Energy Association

Notes on the Report

The results from the focus group have been rearranged to make a more comprehensible report outlining the state of buildings technology, what factors are pushing development and what the implications could be for building design. Possible building scenarios and their effect on future energy technology were also included. Extra details have been added for clarity and drawing conclusions. This document is designed to be a companion to the '*Energy Technology Futures: Illumination and Space Conditioning beyond 2030*' report by Marbek Resource Consultants based in Ottawa, Ontario. A glossary of terms is located at the end of this report for reference purposes.

BUILDING TECHNOLOGY IN THE 2030 – 2050 TIME FRAME

The focus group viewed the area of building science as a “taker of technology” from other sectors. Two of the main reasons for this are the slow capital turnover for buildings and the high initial investment required in their construction. There are many existing technologies available that have not been fully integrated into building practices. The structures being built today will probably still exist in the 2030 – 2050 time frame.

The focus group identified the following factors that could influence the design and operation of buildings over the longer term:

- Energy Conservation
- Urban Design and Infrastructure
- Energy Management and Controls
- Building Flexibility
- Pollution

Energy Conservation

Energy conservation is a large factor in technological development. In regards to the buildings sector, one of the best ways to reduce GHG emissions is through energy conservation. Future energy demand could be much lower than today because of better materials, fenestration, and appliances. Better-sealed building envelopes with recirculating air could minimise energy inputs by reducing leakage. More passive strategies in natural lighting, ventilation, and cooling with better methods of recycling energy may allow us to use fuel more effectively.

Urban Design and Infrastructure

Demographic trends for Canada show continued migration to cities with large urban centres housing a very large percentage (60% or greater) of Canadians. The way urban areas are designed greatly effect how energy is used in cities. Population density, distribution, lifestyle and city services all effect urban space design. Urban areas could become more concentrated or decentralized in the future. Groups of buildings may become self-sufficient or may be interconnected with other communities. Furthermore, changes in designs and service demands could effect how urban infrastructure changes over time.

Small-scale water and wastewater processing, gray water reuse, and small local power plants may make up city infrastructure in the next century. Adjustments in the way power is generated and waste is processed could also change the way buildings interact with the outside environment. There could be a varied mix of distributed and centralized urban services in the next century.

Energy Management and Controls

Advances in digital technology have enabled ever increasing sensing and control over interior environments. Developing more comprehensive sensors with finer controls could change the way a building demands and manages incoming energy. Lighting, heating

and emissions may be optimally controlled through use of technologies such as expert systems or artificial intelligence.

Building Flexibility

Building space could be designed to adapt to different needs through moveable interior walls and adjustable heating and cooling systems. Energy efficient appliances could run on high capacity batteries to make them more portable. This could allow for the rearrangement of space and items throughout a building in a relatively short period of time. As a result, public and office buildings with multiple purposes could be used for more hours a day and year-round serving many different occupants.

Pollution

Minimization of GHG emissions as well as volatile chemicals in living spaces and emissions from power sources within buildings is another factor that was addressed. Issues such as climate change, photochemical smog, and sick building syndrome can be linked to localized urban emissions. Incorporating renewable energy power systems such as solar and wind based technologies could reduce urban pollutant levels from stationary sources. Low emission and zero emission cars would also have tremendous impact. Internal air pollutants could be mitigated with biologically based purification systems and by incorporating materials that degrade without noxious emissions over time. This could bring us to a level where a building is an energy self-sustaining unit.

BUILDING SCENARIOS

The focus group further developed the initial concepts from the morning session into building scenarios. The results of the groups can be incorporated into four models of future building approaches focusing on different aspects the technological drivers.

The Energy Conservation Approach

Buildings designed with a more open concept could take advantage of more passive means of ventilation, heating and lighting incorporated into the design. A centrally controlled air and light distribution system using a solar chimney and operable windows may be used. Automatic shading of windows could be used to reduce air conditioning needs in the summer months. Phase change or crystal structural change materials could be used in the wallboard and flooring to capture and gradually release heat for temperature stabilization.

Artificial illumination advances could take several new directions. Individual environments could have photoluminescent wall surfaces that emit light. These could be electrically or biologically induced. Fibre optic light piping could be used to distribute illumination to the building from a single light source.

Environmental controls like desiccants could be used to control ambient humidity by removing water vapour from the circulating air mass. This means that less energy is used on cooling the building's air mass because it reduces the amount of energy needed to change its temperature. Desiccants could also be regenerated by waste heat producing a more self-sufficient system.

Waste heat could be used in other applications as well. Heat from building gray water could be used to heat parking lots in the winter months or it could also be stored underneath buildings for fire control and summer cooling. Ambient heat from the surrounding environment could be used as well. Heat pumps tap into the relatively stable ground temperature and extract heat in the winter via a compressor or release heat in the summer to air condition the building. Heat pumps can also be adapted to use large bodies of water as heat sources or sinks.

In a building where energy demands are low, power may be produced within the structure or come from district electricity and district heating. Internal energy production with co-generation and some form of energy storage like flywheels could be used to even load requirements. Energy could be extracted from many sources; low-head turbines could generate energy from rain water or gray water from upper floors. These approaches combined with low energy requirements could make buildings zero consumers or even producers of energy.

The New Urban Design Approach

A 'zone of sustainability' concept was identified in this approach. This implies that communities of structures are contained within a zone that uses local resources and processes its own waste. A particular zone may vary in size depending on the availability of certain resources and the appropriate scale for each city service. Gray water lagoons and local sewage treatment centers could be located adjacent to a small collection of buildings. The gray water could be used directly for emergency firewater or for other non-potable water applications. In this approach, recycling, water and wastewater services would be more localized but other services could become more globalized. Electricity, for example, could be traded among different cities and across borders in a global energy network with individual communities as the nodes.

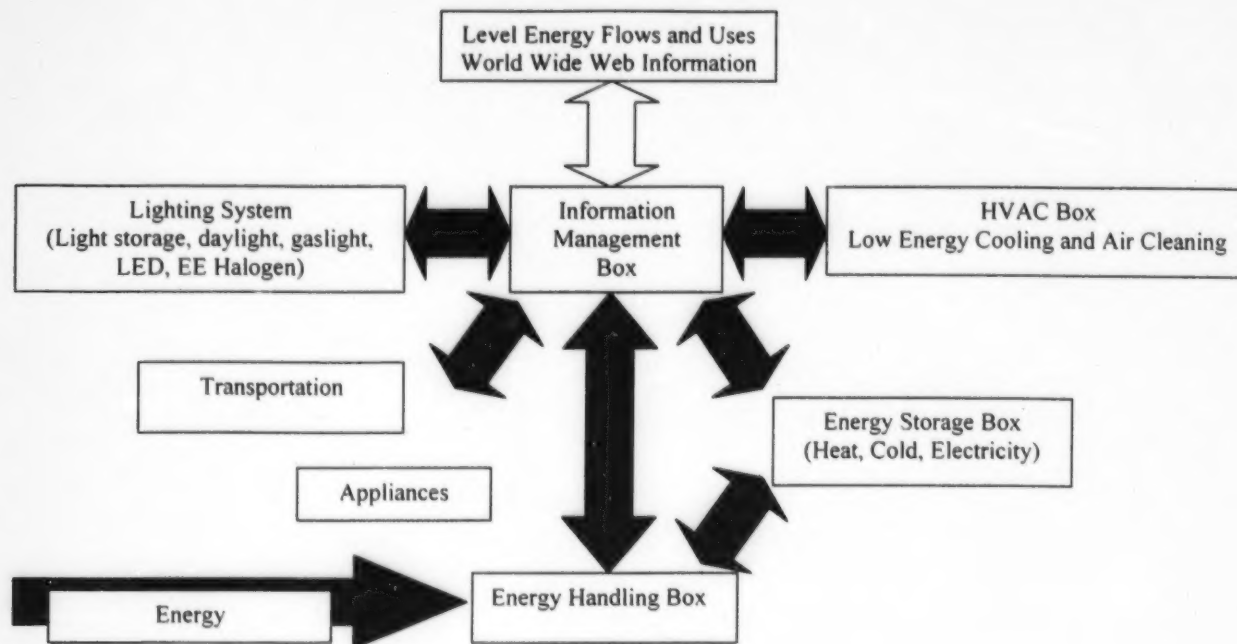
The Integrated System Approach

This system approach is unique due to its versatility. The process begins with a form of energy input; this could be in the form of sunlight, hydrogen, or district heat or electricity. The energy is transformed to electricity through photovoltaics, fuel cells, or by co-generation via an Energy Handling box.

The Energy Handling box then feeds into the homeowner's Information Management box and Energy Storage box. The Energy Storage box may store electricity, heat, and cold in the form of batteries, superconducting capacitors, or phase change materials (See Graphic 1.0).

The Information Handling box is the brain of the unit. It distributes power to appliances, lighting and space conditioning units, and possibly small vehicles for urban transportation. The box processes information from previous usage to develop use patterns to better match energy needs. It could also utilize external information from the Internet such as upcoming weather reports. For example, the unit may receive information that a cold spell is coming so it may allocate more energy to storage thus attenuating energy use peaks. It could also advise the user about needed repairs and upgrades for building components.

The transportation unit could also be linked with the home. Power could go to recharging the vehicle during off peak hours. Communications and power transmission could be wireless via radio and microwaves. The main strength of this integrated approach is the efficient use of resources while maintaining use flexibility.



Graphic 1.0 Energy Flow Chart

The Pollution Free Approach

The goal of this approach was to reduce pollution from end use demands in buildings and from building heat/power sources and components. Such buildings could be constructed with integrated photovoltaics and wind powered generators. These renewable energies could supplement power from a centrally located or external power plant.

In a pollution conscious society, hydrogen may become the fuel of choice. Multiple sources for hydrogen generation including waste heat, photovoltaics, and bio-incineration. Service demands such as cooking could be done with hydrogen or solar systems as well. Other appliances may run on long life batteries recharged in a central location within the building. High capacity batteries could operate for an extended period of time in a low wattage unit.

Building air and waste could be circulated through a biological cleansing process. This would help keep the building's air clean and well oxygenated. Bioprocessing of waste and materials could be done within the building perimeter.

TECHNOLOGY LINKAGES

The following are a collection of technologies that could help meet one or more future requirements. The focus group discussed possible technological innovations in this context. The group felt that research in the following areas would greatly benefit the buildings sector:

Materials

- Carbon fibre reinforced structural materials
- Light weight materials
- Biologically based materials
- Micro-friction materials for moving parts for small generators
- Advanced lumber and other construction materials
- Luminescent wall coverings
- Phase change or structural change materials, preferably at 22° C

Digital Technology

- Further miniaturization of components
- More sensitive and versatile controls and sensors
- Artificial intelligence
- Expert systems
- Fibre optic usage

Biotechnology

- Biologically derived insulation
- Biological purification of water and air streams
- Bioluminescent materials

Enabling Technologies

- Energy storage devices for heat and electricity
- Flywheel technology improvements
- Stationary fuel cells
- Waste reuse and disposal techniques
- Long life batteries with no memory
- Advanced modeling techniques for experimentation of new technologies

Preparing Canada for Building Technology in 2030 - 2050

Canada has a particular outlook as we approach the end of the 20th century. Due to our past history in science, industry, and geographical uniqueness, we have certain strengths on which to build and weaknesses to address.

Our industrial advantages:

- Information technology
- Fuel cell technology
- Telecommunications
- Bioengineering (small firms across country)

Our scientific advantages:

- Cold climate design
- Systems engineering (integration)
- Materials
- Engineered wood products
- Conductive concrete

Our economic advantages:

- Cost competitiveness
- Canadian Energy Code

Public Perception and Policy

Due to the slow capital turnover for buildings and the high initial costs, there are many existing technologies available that have not been fully integrated into building practices. There is also a lack of knowledge in the building industry about advanced products and methodologies.

The homes being built today will probably still exist well into the next century. A great deal of time and money could be required to retrofit existing or inappropriately constructed buildings. New buildings could be built much better even with the knowledge we have today. The Canadian government solution to this problem could be two fold:

- Decide for the public what best technologies they should be using in their buildings through regulations.
- Make it easy for the public to choose themselves by educating everyone involved with the building construction and sale process.

Developing a knowledgeable and receptive population would greatly accelerate the adoption of better technologies. This could develop into a buyer focused marketing plan outlining the benefits of energy saving design and technology. Affordability is also a key area with respect to how quickly new and established technologies can become commonplace. Many environmentally friendly technologies exist at this time, though their high costs prohibit wide spread application.

Glossary of Terms

Anode

Where an electron is added (oxidation) to a molecule in an electrochemical cell.

Cathode

Where an electron is taken (reduction) from a molecule in an electrochemical cell.

Conduction

The movement of heat through a substance by the transfer of energy from more energetic to less energetic particles via atomic or molecular motion. Thermal conductivity is a measure of the substance's resistance to heat loss/gain. The higher the thermal conductivity, the slower heat moves through the substance.

Co-generation

The simultaneous production of electricity and heat in the form of steam or hot water.

Convection

Convection heat transfer consists of two mechanisms:

- 1) Molecular Diffusion: Heat transfer by random molecular motion.
- 2) Bulk Fluid Motion: The movement of a fluid, usually air, over an object as caused by a temperature gradient.

Desiccant Cooling

The use of chemical (or physical) absorption of water vapour to dehumidify air and reduce the latent cooling load in a building HVAC system.

District Energy

District Energy, also known as district heating and cooling, is the technology for providing heating (and possibly other forms of energy) from a central plant to multiple users. The most common district energy technology originally used piped steam to distribute the energy, but currently lower pressure hot water in flexible plastic piping can be used effectively to distribute heating and cooling energy.

Ecological Footprint

Quantification of area required by a city for resource demands such as food, fibre, and energy as well as waste product assimilation. This can be expressed in ecological output of land per human.

Fenestration

Referring to the arrangement, proportioning, and design of windows and doors in a building.

Fuel Cell

A uses a cathode and anode like a battery and uses a constant source of fuel to create energy. Fuel cells do not run down or require recharging; they produce energy in the form of electricity and heat as long as fuel is supplied. The usual reaction within a fuel cell is one between a hydrogen ion and oxygen. In the case of a hydrogen fuel cell, oxygen (from air) passes over the cathode and hydrogen over the anode. Encouraged by a catalyst, the hydrogen atom splits into a proton and an electron, the proton goes through the electrolyte and the electron is diverted to create a current. The atomic parts are reunited thus generating electricity, water and heat. The fuel cell oxidizes without combusting material.

Fuel Reformer

Part of a fuel cell system, a "fuel reformer" uses hydrogen from any hydrocarbon-based fuel like gasoline, natural gas, or ethanol.

Gray Water Recycling

The collection, storage, treatment and redistribution of laundry and bathing effluent for toilet flushing, irrigation, janitorial cleaning, cooling and laundry washing.

Heat Pumps

A ground-source heat pump extracts solar heat stored in the upper layers of the earth. A water source heat pump extracts solar heat from large bodies of water. The steady-state temperature on the earth and water can be as high as 10 degrees in Canada, gradually decreasing in the northern latitudes. These pumps can also cool buildings by reversing the process in the summer.

Phase change/Structural change materials

Materials that absorb heat to change an internal compound from a solid to a liquid (latent heat of vapourization) or to change its crystalline structure without increasing its temperature.

Radiation

Thermal radiation emitted by an object via electromagnetic (visible or non-visible) waves.